ENGINEERING-EDUCATION

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Society for the Promotion of Engineering Education

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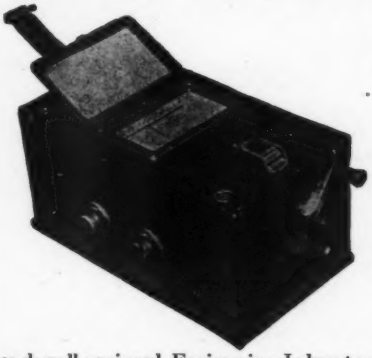

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THEORY OF FRICTION OF V-THREADS.

BY BENJAMIN F. GROAT,

Pittsburgh, Pa.

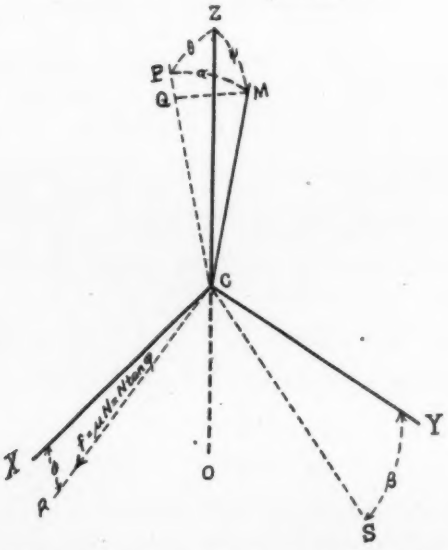
In compiling a paper on the efficiency of the screw,* the author observed that numerous writers have employed the angle β erroneously in the formula for the efficiency of V-threads, β being the angle of slope of the surface of the thread in an axial plane. It was commonly stated that in such

*"Efficiency of the Screw," Proceedings of the Engineers' Society of Western Pennsylvania for June, 1918.

cases the friction is increased in the ratio sec β: 1, whereas, it should have been stated that the ratio is sec α: 1, if α is the angle between the normal to the axis of the screw through the point of application of the resultant of forces and a plane tangent to the surface of the thread at the same point.

This angle is not the same as β and the error may make important differences in calculated efficiencies. Suppose, for example, that $\beta = 30°$, and that the angle of pitch $= 60°$. Then it may be shown that

$$\left.\begin{array}{l}\dfrac{\sec \alpha}{\sec \beta} = 0.9\end{array}\right] \begin{array}{l}\text{pitch} = 60° \\ \beta = 30°\end{array}$$



and that if the pitch is changed to 45°, the ratio is increased only to 0.936, either of which errors in design calculations might be material.

In the accompanying figure take the origin, C, of rectangular coördinates of three dimensions at the point C, on the face

of the "V"-thread at which the resultant of forces is supposed to act. Let the yz-plane be an axial plane of the screw so that the xz-plane is parallel to the axis of the screw and contains the line of action, RC, of the friction along the surface of the thread. If ϕ is the angle of friction and N the normal pressure, the friction is $f = \mu N$, where $\mu = \tan \phi$, the coefficient of friction.

Let θ be the angle of thread slope, which is measured by the angle, θ, in the xz-plane between the x-axis and the trace, RC, of the tangent plane at the origin upon the xz-plane. Similarly the angle, β, is the half angle of the thread and is measured by the angle, β, between the y-axis and the trace, SC, of the tangent plane at the origin upon the yz-plane.

Let ψ be the angle between the normal, CM, to the tangent plane at the origin and the z-axis. Then the normal pressure, N, acts along this normal and its direction cosines will be, l, m, n, yet to be found in terms of the slope θ and thread angle β.

The following table of direction cosines, L, M, N, may then be compiled and the conditions for determining l, m, n, also follow:

DIRECTION COSINES.

	L	M	N
Normal, CM:	l	m	n
Friction line, RC:	$\cos\theta$	0	$\cos(\pi/2+\theta) = -\sin\theta$
Thread line, SC:	0	$\cos\beta$	$-\sin\beta$

EQUATIONS:

Cosine relation:	$1^2 + m^2 + n^2 = 1$
$RC \perp CM$:	$1\cos\theta + 0 - n\sin\theta = 0$
$SC \perp CM$:	$0 + m\cos\beta - n\sin\beta = 0$

Thus $$\frac{l}{n} = \tan\theta \text{ and } \frac{m}{n} = \tan\beta,$$

from which,

$$l^2 = \frac{\tan^2\theta}{\tan^2\theta + \sec^2\beta},$$

$$m^2 = \frac{\tan^2\beta}{\tan^2\theta + \sec^2\beta},$$

$$n^2 = \frac{1}{\tan^2\theta + \sec^2\beta}.$$

If there were no friction the relations between the thrust, T, normal pressure, N, and turning moment, M_t, upon the screw would be:

$$\text{Thrust, } T = nN,$$

$$\text{Moment, } M_t = lN \cdot r = \frac{l}{n} Tr,$$

where r is the radius, or distance from the point, C, perpendicularly upon the axis of the screw.

With friction, the corresponding relations become:

$$\text{Thrust, } T = nN - \mu N \sin\theta,$$

$$\text{Moment, } M_s = lNr + \mu N \cos\theta \cdot r,$$

$$= \frac{l + \mu\cos\theta}{n - \mu\sin\theta} Tr.$$

Therefore the efficiency is:

$$\eta = \frac{M_t}{M_s} = \frac{\dfrac{l}{n}}{\dfrac{\dfrac{l}{n} + \mu\dfrac{\cos\theta}{n}}{1 - \mu\dfrac{\cos\theta}{n}\tan\theta}} = \frac{\tan\theta}{\dfrac{\tan\theta + \tan\phi'}{1 - \tan\theta\tan\phi'}}$$

or,

$$\eta = \frac{M_t}{M_s} = \frac{\tan\theta}{\tan(\theta + \phi')}$$

if $\mu\dfrac{\cos\theta}{n}$ be changed to $\tan\phi'$.

Now $\cos\theta \div n = \cos\theta \sqrt{\tan^2\theta + \sec^2\beta}$,
so that

$$\mu' = \tan\phi' = \mu\sqrt{\sin^2\theta + \frac{\cos^2\theta}{\cos^2\beta}}$$

$$= \mu \sec\beta \sqrt{1 - (\sin\theta \sin\beta)^2}$$

is an equivalent coefficient of friction which may be substituted in the formula for square threads to determine the efficiency for "V"-threads, since $M_t \div M_s = \tan\theta \div \tan(\theta + \phi)$ is the formula for square threads when $\mu = \tan\phi$ is the coefficient of friction.

Observe that

$$\mu' > \mu \text{ since } \sqrt{\sin^2\theta + \frac{\cos^2\theta}{\cos^2\beta}} > 1,$$

by the nature of the functions under the radical.

To show that the factor by which μ must be multiplied to obtain μ' is equal to sec α, where α is the angle between the tangent plane at the point C and the normal from C upon the axis of the screw, notice that this is also the angle between the normal, CM, to the tangent plane, and the xz-plane, as indicated in the figure.

Then, since α, θ, ψ form the three sides of a right-angled solid (spherical) triangle, right-angled opposite ψ, along the trace, CP, we must have,

$$\cos\psi = \cos\alpha \cos\theta;$$

from which

$$\cos\alpha = \frac{\cos\psi}{\cos\theta} = \frac{n}{\cos\theta}$$

and, thus,

$$\sec\alpha = \frac{\cos\theta}{n}$$

But

$$\frac{\cos\theta}{n} = \sec\beta \sqrt{1 - (\sin\theta \sin\beta)^2},$$

as shown above.

Therefore,

$$\sec \alpha = \frac{\cos \theta}{n} = \sec \beta \sqrt{1 - (\sin \theta \sin \beta)^2},$$

which was to be shown.

THE LIFTING MAGNET; A VALUABLE PIECE OF LABORATORY APPARATUS.

BY L. A. DOGGETT AND C. A. STYER.

The magnetic circuit is obviously one of the fundamental concepts of electrical engineering. Any laboratory experiment that can help to make clear to the student the various characteristics of the magnetic circuit is a valuable one. The experiments about to be described bring out the following points: (1) Magnetization curve and saturation, (2) hysteresis effects, (3) law for the pull exerted by an electromagnet, and (4) effects of inductance in an electromagnet. This last item is one which needs more attention than it usually gets. In the class room it is customary to make some effort to get the student acquainted with inductance, but seldom, if ever, in the laboratory. More as to this later.

The lifting magnet used in these experiments is shown in cross section in Fig. 1 and has the following name plate data:

Cutler Hammer Mfg. Co.
Type B Size 18
Serial No. 647144
Volts 220 Duty, Intermittent.

The armature used in these tests was a square piece of cast-iron having machined surfaces and drilled at its center with a three-inch hole, as shown in Fig. 1. This armature was improvised from the materials of the junk pile, and probably much better results would have been obtained with a steel armature thick enough to prevent saturation.

Pull Tests.

Considering first the pull tests, the apparatus was set up as in Fig. 2. In this figure, *M* is the lifting magnet; *A*, the am-

meter; *S*, the controller which is wired as shown in Fig. 3, and *R*, the rheostats for varying the current.

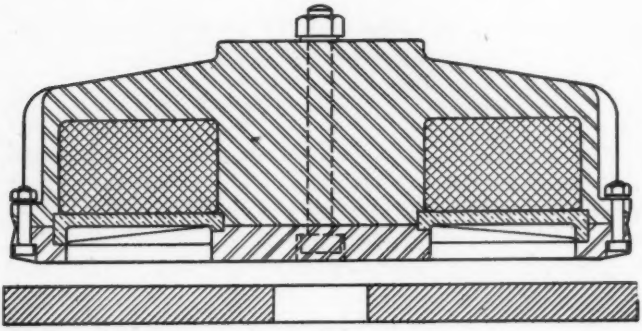


FIG. 1.

The cast-iron plate or armature is plainly visible in Fig. 2. To take observations of the pull, the procedure is as follows:

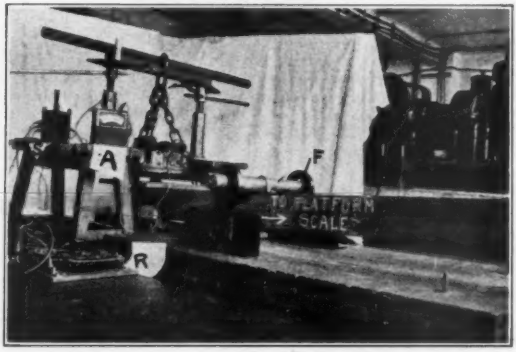


FIG. 2.

The magnet is lowered until the armature is firmly gripped, after which the magnet is raised by the jacks until the wooden

beam is lifted in contact with the fulcrum, *F*. The downward force on the platform scales, not shown in Fig. 2, is then

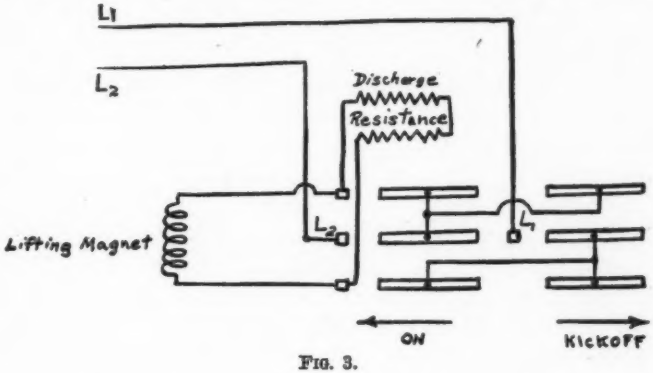


FIG. 3.

weighed. The jacks are then further raised, while the scale beam is being continually balanced and this balancing goes on until the magnet is pulled free from its armature. Table I

TABLE I.

I, Amperes.	Pull, Pounds.	Flux Lines, Inner Pole $\phi_i = 0.46 \times 10^5 \sqrt{\text{Pull}}$.	*I*, Amperes.	Pull, Pounds.	Flux Lines, Inner Pole $\phi_i = 0.46 \times 10^5 \sqrt{\text{Pull}}$.
0.40	906	1,385,000	2.10	3,626	2,770,000
0.50	1,366	1,701,000	2.28	3,916	2,880,000
0.60	1,596	1,840,000	2.54	4,236	2,992,000
0.71	1,976	2,044,000	2.32	3,786	2,830,000
0.81	2,166	2,140,000	2.10	3,686	2,793,000
0.90	2,366	2,232,000	1.88	3,646	2,780,000
1.00	2,356	2,230,000	1.69	3,506	2,721,000
1.12	2,716	2,400,000	1.48	3,276	2,635,000
1.29	2,886	2,470,000	1.30	2,986	2,512,000
1.52	3,146	2,580,000	1.11	2,626	2,360,000
1.70	3,346	2,660,000	0.90	2,356	2,230,000
1.90	3,420	2,690,000	0.70	1,876	1,991,000

gives a set of values for such a test both for increasing and decreasing values of current.

Although a curve of pull *vs.* current might be plotted, it is

more instructive to plot against current the magnitude of the flux of the inner pole, ϕ_i. The relation of flux to pull is

$$\phi_i = 0.46 \times 10^5 \times \sqrt{\text{Pull in Pounds.}}$$

The details of deriving this formula are given in the appendix. Suffice it to say at this point, that the relation between pull and inner pole flux is derived from the fundamental law that

$$\text{pull in dynes per cm}^2 = \frac{1}{8\pi} \times (B \text{ in gausses})^2,$$

and that in calculating B, *effective* air gap areas were used. Furthermore, due account was taken of the fact that only a certain fraction of the inner pole flux enters the outer pole, the rest getting back via leakage paths through the winding space. In Fig. 4 is plotted then a curve of inner pole flux, ϕ_i, *vs.* current. This curve shows very clearly not only saturation from 1.5 amperes on, but also evidences of hysteresis, the observations for increasing currents being plotted as crosses and for decreasing currents as circles.

Thus Fig. 4 illustrates: (1) The magnetization curve and saturation for a magnetic circuit and (2) gives a forceful exhibition of hysteresis effects. In terms of Table I hysteresis accounts for one to two hundred pounds excess in pull when the current is decreasing, over and above the pull for the same increasing current. On the law for magnetic pull depends the method of obtaining the curve of Fig. 4.

Inductance Tests.

Inductance has always been a difficult thing to explain to the beginner. Usually his only laboratory acquaintance with inductance is gained by measuring a reactance with alternating current and then obtaining a quantity which he is told to call the inductance by dividing the reactance by 2π (frequency). It is very possible for him to make this calculation without even a speaking acquaintance with inductance. Hence, we strongly advocate having the student obtain a

curve of the form

$$i = \frac{E}{R}(1 - \epsilon^{-Rt/L})$$

some time during the latter part of his direct current course, being of the opinion that such an experiment will give the stu-

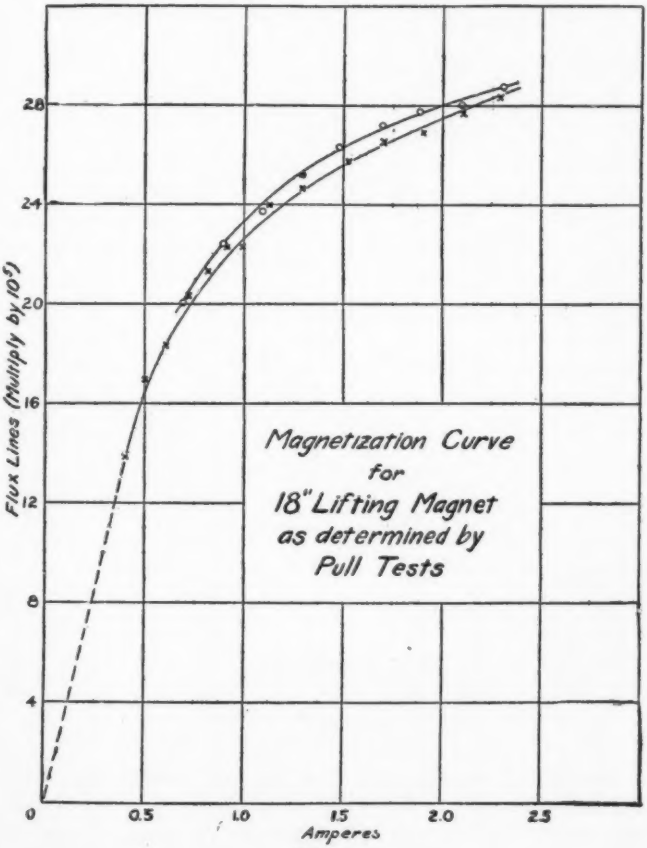


FIG. 4.

dent the sort of physical conception of inductance that will materially aid him both in his alternating current work and in his radiotelegraphy work.

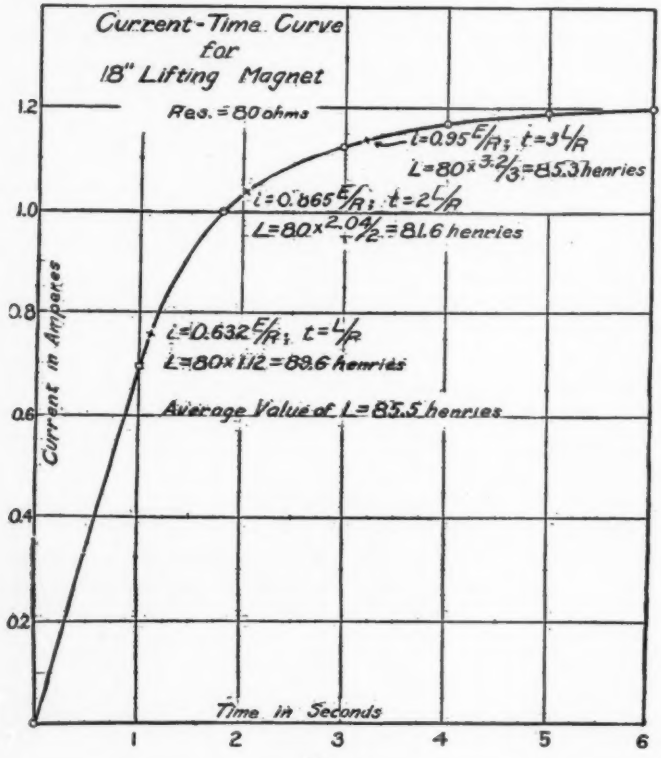


FIG. 5.

The lifting magnet provides a very satisfactory apparatus for this experiment, although of course it is not an apparatus of constant self inductance. However, the curve of Fig. 5, a curve of current *vs.* time brings out the possibilities of this

sort of a test. Here the student can see inductance at work. He can get a rough approximation of the value of the inductance of the magnet, by using the fact that the current reaches 63.2 per cent. of its final value in one time constant, 86.5 per cent. in two time constants, and 95 per cent. in three time constants. The magnet used in these experiments had for various conditions of air gap and current values, inductances of from 50 to 100 henries. The resistance being about 80 ohms, the time constants dealt with varied from $\frac{5}{8}$ to $1\frac{1}{4}$ seconds, values easily measured to a fair degree of accuracy with ordinary stop watches.

In the appendix there is submitted the outline of an experiment along this line, written for the use of elementary students in the United States Naval Academy.

Appendix.

1. Derivation of Pull Formula.

In Table II is given the value of the inner pole flux, ϕ_i, for increasing and decreasing values of current, the flux being determined by a two-turn exploring coil around the

TABLE II.

Current in Amperes.	Flux Lines, Inner Pole by Exploring Coil.	Current in Amperes.	Flux Lines, Inner Pole by Exploring Coil.
0.155	573,000	2.470	2,990,000
0.220	778,000	2.300	2,940,000
0.320	1,126,000	2.000	2,833,000
0.700	1,842,000	1.780	2,740,000
0.900	2,052,000	1.540	2,620,000
1.325	2,426,000	1.330	2,493,000
1.570	2,585,000	0.910	2,145,000
1.850	2,740,000	0.680	1,878,000
2.100	2,840,000	0.325	1,212,000
2.380	2,948,000	0.220	895,000
2.520	2,992,000	0.160	700,000
2.710	3,052,000	0.000	11,010

inner pole of the magnet. The ends of this coil were twisted up and led out through a hole in the outer shell of the magnet

to a ballistic galvanometer. This ballistic galvanometer was calibrated by the usual long solenoid method and hence the data of Table II are not relative but absolute data of a fair degree of accuracy.

Assuming then these data to be accurate, it was obvious for two reasons that all the flux that left the inner pole did not enter the outer pole. The first reason for this conclusion is that the pull would have been much larger than the measured pull if all the inner pole flux entered the outer pole. The second reason is that since the value of inductance calculated on the basis of

$$L = \frac{\phi_i N}{I} \times 10^{-8}$$

for $I = 0.5$ ampere was 160 henries or much too large, therefore not all the inner pole flux entered the outer pole. That there should be a great deal of flux that did not go through the cast-iron armature is obvious when we consider the cross section of the armature and the resulting saturation if ϕ_i were all carried by the armature.

Coming now to the derivation of the formula connecting ϕ_i and pull, start with the fundamental law,

$$\text{Pull in dynes per cm.}^2 = \frac{B^2}{8\pi}.$$

From this may be derived the following:

Total pull of magnet in

$$\text{pounds} = \phi_i^2 \frac{138.5 \times 10^{-10}}{A_i} + \phi_0^2 \frac{138.5 \times 10^{-10}}{A_0},$$

where A_i and A_0 are respectively the effective areas of the inner and outer poles in square inches. Considering the three-inch hole in the armature and making some allowance for fringing $A_i = 34.6$ square inches. Taking account of the fact that the outer pole is not flat but bevelled, $A_0 = 39.7$ square inches. Taking into consideration the data of the pull curves and the data on the inductance, a conclusion was

reached that on the average only about 45 per cent. of the inner pole flux entered the outer pole. Substituting this information, we have

$$\text{Total pull in pounds} = 4.71 \times 10^{-10}\phi_i^2,$$

or with an accuracy sufficient for the present purposes,

$$\phi_i = 0.46 \times 10^5 \times \sqrt{\text{Pull in Pounds.}}$$

2. Sample Inductance Experiment.

INDUCTANCE.

Object.—The object of this experiment is to study inductance.

Apparatus.—An 18-in. Cutler-Hammer lifting magnet. A low-scale ammeter. A stop watch. Rheostats for varying the current. A 220-volt direct-current source of power.

Procedure.—Arrange the armature with an air gap of about 0.25 inch. Set the rheostats so that the final value of current is 1.2 amperes. For 1, 2, 3, 4, 5 and 6 seconds read the value of the current. Read the current ten times for each point.

Measure the resistance of the magnet alone. Measure the resistance of the discharge resistance alone.

Results.—Using average values plot a curve of current *vs.* time. Assuming that the curve you have is a true logarithmic curve (*i. e.*, 63.2 per cent. of final value reached in one time constant, 86.5 per cent. in two time constants, and 95 per cent. in three time constants) calculate three values of the inductance.

Questions.—With the present discharge resistance and an impressed voltage of 220, what is the maximum possible value of voltage across the magnet when the switch is opened?

If the magnet has 5,000 turns, what flux must link these turns to give an inductance of ———————— henries at 1.2 amperes?

References.—Bullard's Naval Electricians' Text Book, Volume I, 1917 edition, pages 110 to 114.

ARMY EDUCATION IN WAR ISSUES.

BY LOUIS K. MANLEY,

Assistant Professor of Economics, University of Pittsburgh.

It requires more than training to make a soldier. The will to fight can make a man valuable in his military unit though his physical qualifications for the army are barely sufficient to pass army standards. A well-trained soldier who is only in part convinced that his cause is one worth fighting for is not worth enough to any army to repay the government that trains him. In Belgium those men whose lot it was to face the Hun on the outskirts of a familiar little village needed no other incentive to fight to the death than the realization of what would happen to their own home folk if the thin little line should break.

In 1914 the causes of the war and the knowledge of what a victory for the Central Powers would mean in Europe were part and parcel of the mental equipment of the soldiers of the Allied European Powers. The aloofness of the United States regarding questions of vital interest to Europeans prevented many individuals in this country from knowing the true situation in Europe. German propaganda in America from 1914 to the time of our entrance into the war was designed so to becloud the actual situation and so to conceal the real purposes of Germany that American sympathy should not have an opportunity to definitely crystallize and align itself with the Entente Allies. In part this propaganda was successful, but only in part.

This was the situation when, in April, 1917, for reasons quite sufficient and too well known to require recounting, the United States declared war upon Germany. Had our issues with Germany been solely those of a type with which the

average American was familiar we could have taken for granted the existence of the point of view which is an essential asset for the successful prosecution of a war. But the complexities of the international situation, the wide circulation by paid agents of Germany of wilful misrepresentation of facts, the strong desire of America to remain at peace if peace were possible with honor, the hesitancy of America to realize that the reported German methods of carrying on war were true, the difficulties of weighing the tremendous mass of diplomatic material which so clearly placed the responsibility of this world war upon the German Empire, all of these combined to make a problem somewhat too difficult for the casual reader to face in such a way that his decision should emerge clear cut. Never before in history has a nation engaged in war for more just reasons or from higher ethical motives than in the case of the United States in its declaration of war upon Germany. Our soldiers and civilians must not merely feel this through chauvinism or blind patriotism but they must know it through actual contact with the bitter truths that show Germany and her allies as they are.

If the United States were raising armies by the volunteer plan, every man in the army would be there because of a personal conviction of duty; but in raising armies by the draft it is obvious that many men are in service who would not have enlisted. We owe it both to the efficient conduct of the war and to the men themselves to see to it that every man in the service of the United States is made familiar with the whole war situation. No sane man placed in touch with the facts could possibly reach any other conclusion than a conviction through which his whole mind and soul would be as thoroughly enlisted in service as his trained body.

Soon after the United States entered the war there were desultory efforts in our cantonments to render to the men a service concerning war information. Later, a Committee on War Education devised a plan of systematic work in "War Aims" as a part of the military training of the soldiers. In

the various institutions to which men were sent for training along mechanical lines, each man was required to attend a one-hour meeting every week for a study of "war aims." Since ordinarily the men left the institution at the end of eight weeks the instruction had to be confined to eight meetings. Usually the following topics were discussed: The International Situation in 1914, The Causes of America's Entrance into the War, America's Accomplishments in the War, The Governments of the Central Powers (autocracy revealed), The Governments of the Allies (democratic principles presented), A Review of the Various Peace Proposals.

Of necessity these subjects required a rather formal presentation. This was only a part of the "war aims" work; a second part consisted of a survey each week of the leading events of the week as shown by the official statements of the governments and by the responsible American and European press; at each meeting during a period of about twenty minutes, the fullest opportunity was given for an interchange of questions and answers between the soldiers and the instructor. The nature of the questions asked revealed interesting and curious viewpoints, some of which innocently reflected the results of German propaganda. Another feature of the course with motor mechanics was the meeting of the instructor with the soldiers in the Y. M. C. A. recreation hut or in the barracks. Here, because of the very informality of the meeting, questions were often discussed which led to a better understanding of various phases of a situation than could possibly have been obtained in the class-room.

In teaching "war aims," the material which is given to the men and from which the instructor secures his information must always be of unquestionable authority and no statement must be made for which authority can not be cited. At no time must the instructor permit his patriotism to beguile him into statements which will not bear the light of investigation. When the week's news is being discussed the men should be warned that, while the events of the week as stated by our

leading press associations are usually correct, the press statements may occasionally be unreliable.

The result of this work has been amazing. The men have been delighted to have their patriotic convictions sustained by fact. Besides profit the men seem to have found pleasure in the course. It is no unusual thing for the instructor to be greeted with applause and it is exceptional for the hour to close without it. Men who have been out on guard duty and who are not required to attend the "war aims" hour will often forego an hour's sleep to attend "war aims." Unquestionably the work in this field has helped to fuse the great mass of material in the minds of the men into the firm conviction of the justice of the American cause and the danger to all democratic institutions of the German type of government.

The results mentioned show why a course in "war aims" was placed upon the army schedule. "War aims" in the student army training corps represented a somewhat different problem. The S. A. T. C. is the training school from which officers for the United States Army are to be selected. In all of the hundreds of colleges taken over, in part, for S. A. T. C. work the "war aims" course is required of all students except a very few of upper collegiate rank and a few others who are carrying work in certain professional schools. Each student taking the course in "war aims" is required to spend nine hours a week in connection with the course,—three of these in the class room and six in a study room under military supervision.

In all of the colleges and universities carrying on S. A. T. C. work the "war aims" course is organized in accordance with directions from Washington signed by the educational director. As a consequence one might expect identical content in the course as offered by various institutions. Anyone who has had occasion at any time to follow a general order through a career of individual interpretation need not be told that the final reactions of the institutions toward a "war aims" course

are capable of considerable variation. In no case however will the spirit of the execution of the order be out of harmony with the purpose of the educational director.

Where the college or university is sufficiently well staffed with men whose special fields of interest and training are such as to particularly equip them for intelligently discussing war problems, a coöperative course in "war aims" is offered. Each specialist takes a group of men and discusses with them the war situation from the point of view of his specialty. The men are then turned over to another specialist in another field and so the work is continued until the prescribed course has been covered. The following subjects were selected by the educational director as desirable for study, from the standpoint of "war aims," history, government, economics, philosophy, and modern literature.

These subjects are not taught with the usual collegiate content. The history is such as will make intelligible the sequence of events which reached their climax in the world war; the government is chiefly designed to contrast the autocratic governments of the Central Powers with the democratic governments of the Allied Powers; the economics is to show the tremendous influence of international economic relations in shaping national policies; the philosophy is to reveal the control of certain German philosophers over German national thought and to direct attention to the trend of philosophical thought among the Entente Allies; the modern literature is to find its opportunity in the presentation of national ideas and ideals as expressed in the literature of the various nations.

In smaller institutions, where the entire field of social science may be taught by one or two men, the "war aims" course will by necessity be shaped accordingly. In such institutions one instructor will doubtless remain with a group until the course is completed. The course as outlined is both broad and deep.

Having a student army training corps does not mean that we are simply placing a large group of men in colleges and

universities for the old time collegiate instruction. The members of the S. A. T. C. are inducted into the United States Army. They are provided for exactly as all other privates in the United States Army are provided for. They receive thirty dollars a month pay. They are placed in the S. A. T. C. solely for the reason that they are to be trained, at the earliest possible moment, for service to the United States government. They do not receive a single hour of instruction that does not have definite military value. They receive no college credit for work taken, though doubtless there will be no objection to any institution granting credit if it wishes to do so. In brief, members of the S. A. T. C. are simply privates in the United States Army undergoing a very special form of training with the possibility of becoming officers if they show sufficient cause. If they fail to show such cause they will remain in the army as privates or non-commissioned officers but will be transferred out of the S. A. T. C.

The officers selected from this group will probably represent our country upon a foreign field. The "war aims" course will have given to them an elementary knowledge of the issues involved in the war. Their patriotism will be more intelligent and their services to the United States more valuable because of their course in "war aims." It is to be hoped that the hurried glimpse these men have had of some institution of collegiate rank will prove a lure that will draw them back after the war for continued study. We must not forget that democracy can never endure where education is not fostered.

AN ANALYSIS OF MECHANICAL ENGINEERING COURSES.

BY C. E. PEARCE,

Assistant Professor of Applied Mechanics and Machine Design,
Kansas State Agricultural College.

Choice of Colleges.

Agricultural (Land Grant) Colleges not connected with State Universities:

1. Kansas (3 terms).
2. Iowa.
3. Purdue.
4. Michigan.
5. Oregon.
6. Pennsylvania.
7. Texas.

Agricultural Colleges combined with State Universities:

8. Cornell.
9. Wisconsin.
10. Ohio.
11. Nebraska.
12. Kentucky.

State Universities not connected with Agricultural Colleges:

13. Kansas.
14. Michigan.
15. Iowa.
16. Colorado.

Privately Endowed Colleges:

17. Mass. Inst. of Tech.
18. Lehigh.
19. Carnegie Inst.
20. Case School.
21. Armour Inst.
22. Worcester Polytech.
23. Leland Stanford.
24. McGill (Canada).

Subject Headings.

Arts Group:

1. English.
2. Public Speaking.
3. Modern Languages.
4. History and Civics.
5. Economics.
6. Business Law.

Science Group:

7. Chemistry.
8. Physics.
9. Lower Mathematics.
10. Calculus.
11. General Drawing.
12. Descriptive Geometry.

Technical Group:

13. Wood Work.
14. Foundry.
15. Forge.
16. Machine Shop.
17. Metallurgy.
18. Engineering Drawing and Design.
19. Factory Engineering and Design.
20. Engineering Mechanics.
21. Hydraulics.
22. Steam and Gas Engineering.
23. Heating, Ventilation, and Refrigeration.
24. Power Plant Engineering and Design.
25. Electrical Engineering.
26. Surveying.
27. Seminar.
28. Thesis.

Miscellaneous Subjects:

29. Arts Group.
30. Science Group.
31. Technical Group.

Elective Subjects:

32. Arts Group.
33. Science Group.
34. Technical Group.

Subdivisions, from No. 18 to No. 24, inclusive:

x. Time in Recitations and Lectures.
y. Time in Drawing Room Work.
z. Time in Testing Laboratories.

EDITORIALS.

The Report of the Joint Committee on Engineering Education.—The report of the Joint Committee on Engineering Education by Dr. C. R. Mann is now in the hands of all members of this Society. It represents the result of years of study not only by Dr. Mann himself but by individual members of the committee, many of whom devoted a large amount of time to this subject. It has been the subject of discussion at numerous meetings not only of this but other engineering societies. A special committee was appointed at the Northwestern meeting to consider this report in detail and report at the annual meeting next June. Due to the war and the establishment of the S. A. T. C. this epochmaking report has not as yet received the consideration which it should. However, some institutions are already considering the modification of their courses to meet the recommendations in this report. Perhaps, the most important of these is that which deals with the coöperative work, which provides actual practical engineering work for the student while he is taking his course, thus insuring his familiarity with engineering work before he completes his theoretical course. The report deals at length with the system originated and developed by Dean Schneider at the University of Cincinnati. It does not recommend the adoption of this exact form but some method which may be devised to insure the student securing the necessary training in engineering industries.

Membership.—The membership of this Society has remained practically stationary during the war. With the signing of the armistice and the returning of many instructors to the colleges, the membership should be increased so that the Society can do efficiently and well the work which it should do. Every member of the Society should consider himself a member of the Membership Committee to encourage especially the younger members of the teaching profession to not only become members of the Society but to write papers for ENGINEERING EDUCATION, be present at the annual meetings and take part in the discussion.

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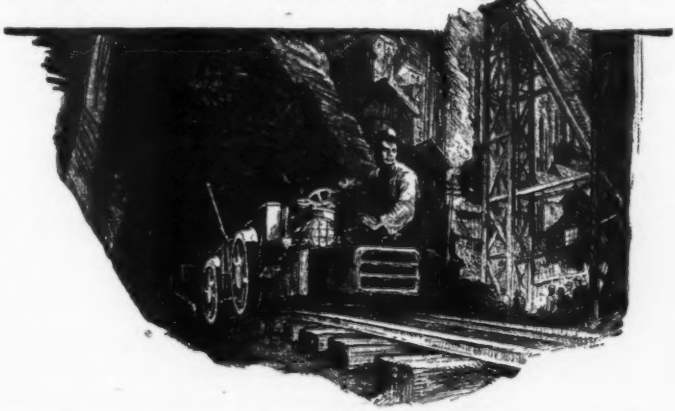

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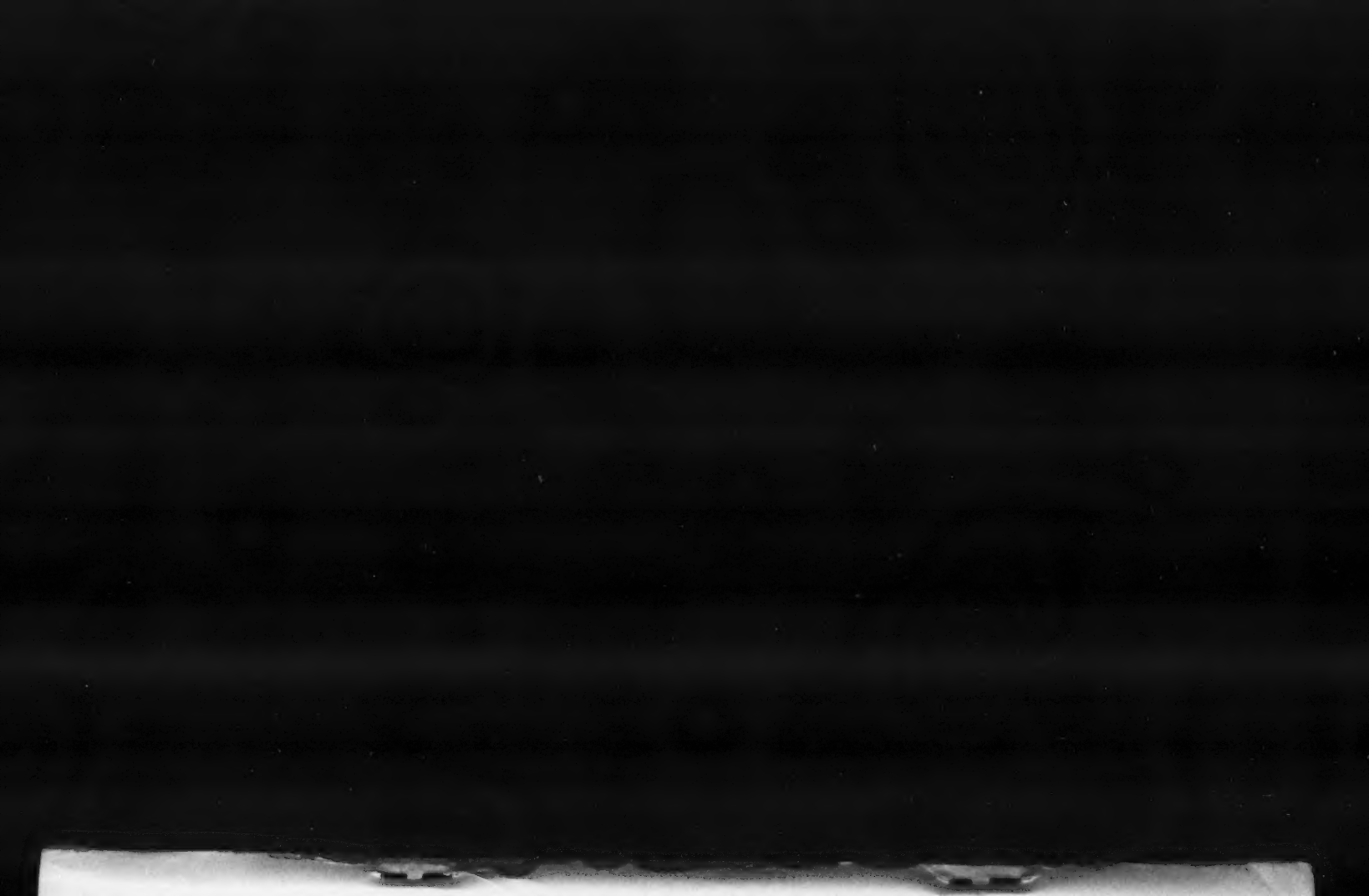

The Bulletin of the Society for the Promotion of Engineering Education

PUBLICATION COMMITTEE
John F. Hayford, Milo S. Ketchum, F. L. Bishop

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